The feeding ecology of greater frigatebirds *Fregata minor* and lesser frigatebirds *F. ariel* on Aride island

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Abstract: The behaviour of frigatebirds on Aride island is described. Kleptoparasitic attacks were made by both greater and lesser frigatebirds. For lesser frigatebirds most attacks were made by males, for greater firgatebirds most attacks were by juveniles. Almost half of all attacks were on wedge-tailed shearwaters; a total of 10 bird species were observed to be attacked. 10 cases of hyper-kleptoparasitism were observed by common noddies.

Keywords: aggression, kleptoparasitism, Seychelles

There are large numbers of roosting frigatebirds *Fregata* spp. found on Aride island; almost 4000 were recorded in November 1996 and 1999, with a maximum of 4555 in 1998 (Betts 1997; Bowler & Hunter 1999). Although they have never attempted to nest there (the main regional nesting ground is Aldabra), their stunning aerobatics and kelptoparasitic hunting methods are a dramatic sight around Aride. Two species are present; greater frigatebirds *Fregata minor* (Gmelin, 1789) and lesser fregatebirds *F. ariel* (Gray, 1832).

Frigatebirds are notorious for their airborne piracy, stimulating early observers to conclude that it was their sole method of feeding. In fact, a small proportion of the food supply in any frigatebird population stems form this source, although some individuals may subsist mostly by piracy (Nelson undated). conflicting reports exist about the nature, extent and success of piracy and, although studies have been carried out on a number of island colonies (the Galapagos, Aldabra and Christmas Island), little is known about the colony on Aride.

Frigatebirds have a highly-specialised feeding technique - snatching flying fish and squid from the surface, for which their long, thin bills are ideally suited, supplemented by kleptoparasitism on the abundant bird species, conducted mainly in impoverished seas. Other attacks and feeding behaviour, such as snatching offal and carrion from the sea, killing newly fledged young of small seabirds such as shearwaters and toying with incapacitated birds on the surface of the water, are considered to be unimportant opportunistic events (Nelson undated).

The aim of this study was to observe the feeding behaviour of the frigatebirds population on Aride island, and their kelptoparasitic behaviour in particular. From observations of feeding methods the effects of kleptoparasitic attacks on the nesting seabird population was to be determined.

Methods

Initially, random observations were made at various points around the island, to determine the ideal location from which to observe the frigatebirds feeding. Due to the high incidence of nesting seabirds across the island during the study, access was restricted and

optimum locations were limited. Five locations were eventually chose: 'Richard's Rock' (RR) on the north-east end of the island, a high rocky cliff promontory over-looking Ti L'Anse (GR: 52773457); 'Cote Desiree', at the east end of the south beach (GR: 52433428); 'La Pointe L'Anse', at the west end of the south beach (GR: 51753434); the 'Western Beach' (WB), a rocky promontory overlooking a small bay at the west end of the island (GR: 51323474); and the 'North-West Rocks' (NWR), a large flat granite slab on the north-west shore of the island, approximately 300m west around the coastline from the base of the 'Gros La Tete Lookout' (GR: 51403480).

Observation days in June-august 1999 were divided into three watch periods: morning (07:00-10:00hrs), midday (10:00-14:00hrs) and afternoon/evening (14:00-18:00hrs). Observations were made randomly at the different locations. Frigatebirds were most frequently and more reliably observed feeding along the north/north-west coasts (close to their established roost sites).

Attacks on other birds were watched through 10X binoculars. Where possible the observations were categorised according to species (lesser/greater), age (juvenile/adult), the number of individuals involved and whether any other species of seabird joined in the attack. Species identifications were uncertain during periods of low light, poor weather conditions and when attacks occurred far from the shore (beyond the effective range of the binoculars). In such situations a record of the attack, its duration, number of birds involved and success was made.

Recording of an attack started from the moment a frigatebird went into an attacking stoop (wings folded, head straining forwards, dropping vertically after the victim at high speed). An attack was considered unsuccessful if:

i) the victim escaped unharmed using evasive manoeuvres
ii) the frigatebird broke off the attack
iii) the victim managed to reach the safety of dry land

An attack was considered successful if:

i) the victim regurgitated its catch into the sea and the pursing frigatebird caught the 'prize' from the surface (categorised as 'successful regurgitation')
ii) the victim was caught by the wings and seriously/mortally injured (considered to be 'killed') whilst also dropping its catch
iii) a victim when harassed in the air dropped its catch; the frigatebird would then attempt to catch the 'prize' in mid-air

During the attack other behavioural details were noted, such as the flight pattern of an attacking group (a rolling or massed attack), whether it was a co-ordinated pair attack (male and female), the flight pattern (rolling or direct) and whether the frigatebird flew into the sea. The behaviour of other seabirds and their influences on the attack result were also noted.

Results

Over 27 days, 59 hours of observations were collected on a total of 687 birds (frigatebirds and other seabirds) involved in 254 attacks on 287 seabirds. On 6 days no attacks were seen (2 of these being days of heavy rain), possibly due to low numbers of feeding seabirds. A total of 3,943 seconds of attacking behaviour was observed, each attack taking 15.5 seconds on average (sd = 17.68, range = 2-150).

The results are summarised in Table 1-2. 38.6% (n=98) of attacks were successful (regurgitation seen), of which 29.5% (n=29) were confirmed 'kills' through wing-biting or 'mobbing' of the victim on the surface. On one occasion, a large group of frigatebirds attacked a shearwater 'raft' causing mayhem. Of the total confirmed attack attempts 61.4% were unsuccessful, of these only 0.26% of victims escaped to dry land.

On 10 occasions (3.93%) a common noddy *Anous stolidus* (Linnaeus, 1758) was present to steal the discharged fish from a harassed victim, before the frigates had a chance to circle round to collect their prize. Only on two other occasions were other seabird species seen to join in with the attack (a lesser noddy, *Anous tenuirostris* Temminck, 1815 and a wedge-tailed shearwater *Puffinus pacificus* Gmelin, 1789. On one occasion, and a sooty tern *Stena fuscata* Linnaeus, 1766 on the other).

7.08% (n=18) of attacks were made in mid-air with the frigatebird hitting the victims whilst on the wing, usually carrying food in the beak. These attacks were mainly on white tailed tropicbirds (*Phaethon lepturus* Lácèpede & Daudin, 1802) and fairy terns (*Gygis alba* Sparrm, 1786). The two instances in which greater frigatebirds were recorded chasing lesser frigatebirds were conspicuous as it was after the lessers had scooped up and were carrying food of their own. There were many other cases of the two species chasing each other but none of these were categorised as attacks during this study.

A number of times (1.2%, n=3) pairs of lesser frigatebirds were observed hunting together. For the purposes of this study this was called a 'paired rolling attacks'. Either of the pair would execute a stooping attack on the victim, chasing it low over the surface of the sea for a number of seconds, whilst the second bird would climb steeply and at an optimum moment dive down at great speed, usually hitting the victim with considerable force. The second bird would continue the low-level chase while the first proceeded to climb and repeat the attack, instigating a rolling pattern. This usually continued until the victim regurgitated,

Table 1. Identity of aggressors

N=667	% of attacks	% males	% females	% juvenile
Lesser fregate	46.5	52.2	12.6	35.1
Greater fregate	46.5	8.3	12.6	79.0
Common noddy	1.7			
Sooty tern	0.3			
unidentified	5.0			

Table 2. Identity of victims

N=287	% of victims	species	% of victims
Wedge-tailed shearwater	48.1	Common noddy	6.6
Lesser noddy	17.7	Audubon's shearwater	3.8
White-tailed tropicbird	13.5	Lesser frigate	0.7
Sooty tern	13.5	Greater frigate	0.7
Fairy tern	7.3	Roseate tern	0.3

was incapacitated on the water, escaped or was killed.

6 instances (2.36%) were recorded of 'pack rolling attacks'. This was a similar hunting pattern to the one described above, but involving greater number of birds, sometimes up to 30 attacking a single victim. These hunting patterns were in marked contrast to the apparent frenzy which ensued, if an individual started an attack in the presence of significant number of other hunting bids. It is worth mentioning that after one of these frenzies a juvenile greater frigate was seen to fly into the sea. After 5 seconds of considerable effort, it managed to become airborne again after avoiding becoming totally waterlogged.

Discussion

During the study the numbers of frigatebirds of both species increased from 600 to 1360 individuals, the highest counts since records began in 1987 (Bowler & Hunter 2000). The high population of birds accounts for the large numbers of birds seen feeding off the north of the island early in the 'season', this in turn accounts for the high sample numbers of attacks observed during the study.

Differentiation between species, sex and sexual maturity was extremely difficult during the full population counts carried out from the boat, although the high proportions of juveniles of both species and of lesser fregate males observed during the attacks may give some indication as to the proportions present at the time. Lesser fregates appear to be over-represented in attacks (forming only 1.2% of the populaiton in 1990 (Castle & Mileto 1990). Of the greater frigate population juveniles appear to attack more than expected (forming only 27% of the population - Castle & Mileto 1990). These 1990 data are supported by more recent observations (lesser fregates forming 4-18% of the popualtion in 1999 - (Bowler & Hunter pers. comm.). It is speculation whether this influences the number of attacks and other behaviour of the frigatebirds at the time, but the high incidence of juveniles making attacks could suggest that Aride is a proving ground for the hunting skills of the birds. Indeed, juveniles were often observed apparently 'playing' with their victims long after they had regurgitated their catch or harassing them on the surface of the water for no apparent reason. It has been mentioned that low fish stocks in the ocean have led to bird species resorting to desperate measures to obtain food, evidence of which exists in this study, with instances of kleptoparasitism being practised by seemingly non-aggressive species (e.g. common noddies and sooty terns). Could this account for the apparent motiveless aggression of the frigatebirds?

Nelson (undated) suggested that this behaviour only occurs in impoverished seas, and that the high number of juveniles apparently practising their hunting techniques could be accounted for by development of their specialised feeding ecology: "Impoverished pelagic habitat and/or specialised feeding techniques lead to slow growth of young and an extended post fledging period to enable the acquisition of specialised feeding techniques(s)". He also suggests that the practice of stealing objects in the air as exhibited by many of the young is a simple form of piracy practised while still immature, but does not explain the conspicuously vindictive behaviour as shown by the high proportions of juveniles frigatebirds (of both species) around Aride.

To substantiate this claim with regard to the Aride population, data on the status of fish stocks in the frigatebird breeding ground at Aldabra would need to be acquired and

comparison made with the status of fish stocks around Aride, to deduce why this year, such large numbers of birds have migrated north so early and exhibited this kind of behaviour.

The principal victims of the frigatebirds around Aride were wedge-tailed shearwaters (in contrast to Bullock's (1989) claim that the main prey are tropicbirds, common noddies and lesser noddies), although from the study it is clear that almost any bird may be chased by frigatebirds, including each other. On Aldabra the principal victims are red-footed boobies *Sula sula* (Linnaeus, 1766), whose distribution is closely matched by that of greater frigatebirds (Nelson undated), although this obviously is not the case around Aride. Maybe in this instance it is just a case of the largest and most successful number of feeding seabirds around the time. The data in Table 2 indicate that the frigatebirds are not simply attacking the most abundant species (comparing the rank of victim identity and seabird census data [Bowler & Hunter 2000] gives Spearmann's $r=0.367$, $P_2>0.2$).

According to Nelson (undated) adults of both species chase, but unequally, with greater frigate males chasing more often than females (Galapagos), greater females chasing more than males (54:2) (Christmas island) and females chasing more than males for both species on Aldabra. Around Aride however, lesser frigate males chased more than females, with similar numbers of both sexes of greater frigates carrying out airborne piracy. Regional variations in food source and sex ratios within the population may influence observations.

Most of the chases around Aride occurred in the late afternoon, when many seabirds were returning from the sea with full crops. It is clear that frigatebirds do not chase indiscriminately but choose their victims carefully. At the time of the study however, it is worth noting that large numbers of nesting seabirds would also be returning from feeding with full crops specifically to feed their nesting young. This, coupled with the constant influx of 'new' frigates migrating from Aldabra, could explain why the number and intensity of attacks increased as the nesting season progressed (and consequently the seabird chicks matured and began demanding more food). Whether this is another factor influencing the protracted nature of many of the attacks around Aride for a large 'prize' is speculation, but on Aldabra Nelson (undated) found that the frigatebirds would often quickly abandon a pursuit of boobies, presumably in response to some undetected cue. If this was the case around Aride, then a correlation must also be drawn between all these factors and the sexual maturity of the frigatebirds; the immature birds showing a tendency to continue chasing (without success) long after old frigates would have abandoned the pursuit.

Despite this eagerness to pursue it is apparent that the success rate of frigatebirds practising kleptoparasitism in general is relatively low and that in fact most frigatebirds actually get most, if not all their food by snatching flying fish and squid from the surface of the sea. For example diamond (1973) found that in only 18% of the 55 attacks observed did a frigatebird obtain food regurgitated by a booby. Similarly, greater frigates in the Galapagos have a 12% success rate (Nelson undated), although it may be as high as 63% on Christmas island (Schreiber & Ashmole 1970). The 38.5% success rate for Aride is much higher than the Aldabra rate and, although this may be due to the difference in sample sizes, other factors such as lack of natural food availability to stimulate kleptoparasitism and high predator to prey ratio could also influence the result.

At first glance, it appeared that the amount of energy and effort expended during each attack, was vastly disproportionate to the small amount of food gained; although from

continual observation, either the attacker or victim (if it escaped physical damage) seemed relatively fresh even after the more prolonged attacks. Both have adapted to spending long periods of time on the wing, so it is only logical to assume that either could sustain prolonged periods of attacking with relatively little additional sustenance and few detrimental effects on their physiology. Anyway many of the attack periods (early morning or late afternoon) were short-lived, based on the numbers of returning birds laden with food.

Hyper-kleptoparasitism was first observed off Aride in 1999 (J. Bowler pers. comm.) when a common noddy was observed following in the path of an attacking group and continually 'stealing' the stolen food from underneath the kleptoparasitic frigatebirds. Several (10) additional observation of this unusual behaviour by common noddies were observed after this sighting, which suggests that it is more common than one would imagine. Maybe it is another case of hungry species adapting to more desperate measures to obtain food in impoverished seas. If this is the case, then it may be possible that other species would begin to adapt in the near future. Alternatively, it could be another example of opportunistic hunting, as exercised by the frigates themselves.

It does seem curious however, that in 1987, it was suggested that the majority of birds parasitised by frigatebirds were in fact common noddies (Bullock 1989). It is possible therefore that significant adaptive behaviour within such a small population, seems to have occurred even within such a short time (although the observations made in 1987 were not extensive and conclusive) and may be just another example of the unique dynamics that are occurring within the Aride ecosystem.

Conclusion

From this study it is clear that although piracy on seabirds by the frigatebirds can appear extremely traumatic and vicious at the time, due to the low success rate and opportunistic nature of the attacks, it is unlikely that they are having a significant detrimental effect on the nesting seabird populations of Aride. The fact that many of the perpetrators and the nature of the attacks at the time of the study were juveniles, could suggest that Aride is a training/proving ground for the highly specialised hunting methods required by the frigatebirds.

High numbers of nesting seabirds across the island and the requirement for seabirds to bring in food for their young are significant factors influencing the number and success of attacks at the time. The instances of hyper-kleptoparasitism are significant in that they may either be an indication of poor food levels available in the sea, or an example of specific adaptive behaviour.

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